CLAIMS

We claim:

1.   A computerized method for dental imaging comprising:

        receiving a plurality of two-dimensional images of a oral cavity; and

        generating at least one three-dimensional image of the oral cavity from the

            plurality of two-dimensional images.

2.   The computerized method of claim 1, wherein the plurality of two-dimensional images further comprises a plurality of two-dimensional optical images.

3.   The computerized method of claim 1, further comprising:

        constructing a physical cast of the oral cavity from the three-dimensional image.

4.   The computerized method of claim 1, further comprising:

        generating the plurality of two-dimensional images of the oral cavity from a

            common reference point in three-dimensional space.

5.   The computerized method of claim 1, wherein the generating further comprises:

        generating shape-from-shading data from the plurality of two-dimensional images

            using a shape-from-shading process, the shape-from-shading data

            comprising a first plurality of three-dimensional points;

        generating range data comprising a second plurality of three-dimensional points

            from the plurality of two-dimensional images using a range-data process;

        fusing the range data to the shape-from-shading data, yielding fused data

            comprising a third plurality of three-dimensional points;

        registering the fused data, yielding registered data comprising a fourth plurality of

            three-dimensional points; and

        triangulating the registered data, yielding the at least one three-dimensional image

            of the oral cavity.

5   6.   The computerized method of claim 5, wherein the generating shape-from-shading data further comprises:

estimating the direction of the illuminant from the plurality of two-dimensional images, in reference to camera intrinsic parameters; and

determining a solution to a brightness equation, yielding the shape-from-shading

10   data comprising a first plurality of three-dimensional points.

7.   The computerized method of claim 5, wherein the fusing the range data to the shape-from-shading data further comprises:

calculating the error difference in available depth measurements of the range data

15   and the shape-from-shading data;

approximating a surface the fits the error difference, yielding an approximated surface; and

correcting the shape-from-shading data from the approximated surface, yielding

fused data comprising a third plurality of three-dimensional points;

20   8.   A computer-readable medium having computer-executable instructions to cause a computer to perform a method comprising:

receiving a plurality of two-dimensional optical images of an oral cavity; and

generating at least one three-dimensional image of the oral cavity from the

25   plurality of two-dimensional images.

9.   The computerized method of claim 8, further comprising:

constructing a physical cast of the oral cavity from the three-dimensional image.

30   10.   The computerized method of claim 8, further comprising:

generating the plurality of two-dimensional images of the oral cavity from a

common reference point in three-dimensional space.

11.   The computerized method of claim 8, wherein the generating further comprises:

generating shape-from-shading data from the plurality of two-dimensional images

using a shape-from-shading process, the shape-from-shading data

comprising a first plurality of three-dimensional points;

generating range data comprising a second plurality of three-dimensional points

from the plurality of two-dimensional images using a range-data process;

fusing the range data to the shape-from-shading data, yielding fused data

comprising a third plurality of three-dimensional points;

registering the fused data, yielding registered data comprising a fourth plurality of

three-dimensional points; and

triangulating the registered data, yielding the at least one three-dimensional image

of the oral cavity.

12.   The computerized method of claim 11, wherein the generating shape-from-shading data further comprises:

estimating the direction of the illuminant from the plurality of two-dimensional

images, in reference to camera intrinsic parameters; and

determining a solution to a brightness equation, yielding the shape-from-shading

data comprising a first plurality of three-dimensional points.

13.   The computerized method of claim 11, wherein the fusing the range data to the shape-from-shading data further comprises:

calculating the error difference in available depth measurements of the range data

and the shape-from-shading data;

approximating a surface the fits the error difference, yielding an approximated

surface; and

correcting the shape-from-shading data from the approximated surface, yielding

fused data comprising a third plurality of three-dimensional points;

14.   A three-dimensional digital image of a human oral cavity produced by the process

comprising:

generating a plurality of two-dimensional optical images of the oral cavity from a

common reference point in three-dimensional space;

generating shape-from-shading data from the plurality of two-dimensional images

using a shape-from-shading process, the shape-from-shading data

comprising a first plurality of three-dimensional points;

generating range data comprising a second plurality of three-dimensional points

from the plurality of two-dimensional images using a range-data process;

fusing the range data to the shape-from-shading data, yielding fused data

comprising a third plurality of three-dimensional points;

registering the fused data, yielding registered data comprising a fourth plurality of

three-dimensional points; and

triangulating the registered data, yielding the one three-dimensional image of the

oral cavity.

15.   The three-dimensional digital image of a human oral cavity of claim 14, produced

by the process wherein generating shape-from-shading data further comprises:

estimating the direction of the illuminant from the plurality of two-dimensional

images, in reference to camera intrinsic parameters.

16.   A system for dental diagnosis comprising:

a processor; and

software means operative on the processor for generating a three-dimensional

image of a human jaw, including generating shape-from-shading data that

is generated from a direction of an illuminant of the jaw that is estimated

in reference to camera intrinsic parameters.

17.   A computerized system comprising:

a digitizer providing five degrees of freedom, having an arm;

a charge coupled device camera, rigidly mounted on the arm of the digitizer; and

a computer, operably coupled to the digitizer and the camera; receiving coordinate

measurements from the digitizer and a plurality of two-dimensional

images from the camera; and generating a digital three-dimensional model from the coordinate measurements and from the plurality of two-dimensional images.

18. The computerized system of claim 17, further comprising:

a rapid prototyping machine operably coupled to the computer, receiving the digital three-dimensional model and generating a physical model of the digital three-dimensional model.

19. The computerized system of claim 17, further comprising:

a display operably coupled to the computer, receiving the digital three-dimensional model and generating an image of the digital three-dimensional model.

20. The computerized system of claim 17, the computer further comprises:

a computer readable medium comprising means of:

generating shape-from-shading data from the plurality of two-dimensional images using a shape-from-shading process, the shape-from-shading data comprising a first plurality of three-dimensional points;

generating range data comprising a second plurality of three-dimensional points from the plurality of two-dimensional images using a range-data process;

fusing the range data to the shape-from-shading data, yielding fused data comprising a third plurality of three-dimensional points;

registering the fused data, yielding registered data comprising a fourth plurality of three-dimensional points; and

triangulating the registered data, yielding the one three-dimensional image of the oral cavity.